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JPRS L/8953

27 February 1980

USSR Report

SPACE

(FOUO 3/80)

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USSR REPORT

SPACE

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I. SPACE SCIENCES

CHANGE IN THE PARAMETERS OF SATELLITE MOTION AND DENSITY OF A SIMPLE LAYER AT THE EARTH'S SURFACE

Moscow ISSLED. PO GEODEZII, AEROFOTOS'YEMKE I KARTOGR. in Russian No 3/1, 1978 pp 84-89

YEREMEYEV, V.F., YURKINA, M.I.

[From REFERATIVNYY ZHURNAL, 62. ISSLEDOVANIYE KOSMICHESKOGO PROSTRANSTVA, OTDEL'NYY VYPUSK No 10, 1979 Abstract No 10.62.303 by A. Mikisha]

[Text] The paper examines the problems involved in the geodetic use of solution of the problem of motion of a point in the field of attraction of two fixed centers. The closeness of the potential for the field of attraction of the geodetic reference ellipsoid U, found by M.S. Molodenskiy, to the potential of attraction of two fixed centers V enabled the authors to represent the potential of the earth's attraction in the form:

$$W = V + R = V + \int_S \frac{\Phi}{r} ds + \Delta W,$$

where R is the perturbing potential, Φ is the density of the simple layer, ΔW is the aggregate of the correction terms, one of which contains an unknown parameter, $(W_0 - U_0)$ is the potential difference at the beginning of scale height. A precise solution of the problem of the motion of a point in the potential field V is used as "unperturbed," and then by the method of variation of constants (the so-called Lagrange method) a correlation is established between the unknowns Φ and $(W_0 - U_0)$ with changes in the orbital parameters. The authors discuss the possibility of use of the derived correction equations in the processing of Doppler, laser or altimetric orbital measurements. It is noted that the mentioned equations can be used both in solution of the inverse problem--refinement of the gravitational field on the basis of orbital measurements and in the solution of the direct problem--detailed determination of satellite motion in the known gravitational field. The latter problem arises, for example, in a study of the motion of the pole on the basis of the results of Doppler tracking of polar satellites. In this case the use of the traditional expansion of geopotential into a series in spherical functions is inapplicable due to the presence of the error from the dropped terms in the series, which cannot be taken into account, but the method developed by the authors does not give this error if the earth's gravitational field has been studied in adequate detail in regions close to satellite trajectories. References: 15.
[93-5303]

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CSO: 1866

APPROVED FOR RELEASE: 2007/02/08: CIA-RDP82-00850R000200050055-4

REGISTRY OF TRANSIENT RADIATION FROM ELECTRON COSMIC RAYS

Moscow PIS'MA V ZhETF in Russian Vol 29, No 8, 1979 pp 497-500

GUSEV, A.A., ZATSEPIN, V.I. PUGACHEVA, G.I. TITENKOV, A.F.

[From REFERATIVNYY ZHURNAL, 62. ISSLEVOVANIYE KOSMICHESKOGO PROSTRANSTVA, OTDEL'NYY VYPUSK No 10, 1979 Abstract No 10.62.135 by B. Savin]

[Text] This paper gives the results of x-ray transient radiation (XTR) measuresments and also computed ionization and energy spectrum curves. The measurements were made on the "Intercosmos-17" artificial earth satellite using an instrument which contained three XTR detectors, each of which contained a radiator of 100 mylar films 12.5μm thick, separated by 750-μm intervals, and a porportional counter with a beryllium window (250μm) and a working volume with a thickness of 1.5 cm, filled up to 0.95 atm with a mixture of 95 percent Xe and 5 percent CH. The total energy release in the proportional counter from a charged particle and XTR quanta was measured using a 16-channel amplitude analyzer which was controlled by a telescope of scintillation and Cerenkov counters and a shower calorimeter. This telescope registered individual singly-charged relativistic particles with an energy release in the calorimeter $\gtrsim$ 1 GeV. The telescope was periodically covered by a lead filter (3t units) and ensured the registry of either the total flux of relativistic electrons and protons or only relativistic protons. The article gives the computed distributions of energy releases in the proportional counter created by protons and electrons with energies $\geqslant$ 1GeV. The authors give the computed differential spectra of XTR quanta escaping from a mylar radiator and absorbed in the counter for energies of primary electrons 0.5, 1.3, 5 GeV. The mean energy of an XTR quantum is slightly dependent on the energy of an electron and is 9.2 KeV. The computed distribution of ionization in the counter, found by the Monte Carlo method for the differential spectrum of primary electrons dN/dE-$AE^{-\gamma}(\gamma + 2.5\text{-}3)$, agrees well with the experimental distribution. They both differ appreciably from the experimental distribution for protons. The mean ionization in the computed distribution is 25.5 KeV; the mean number of XTR quanta per one electron with an energy $\geqslant$ 1 GeV is equal to 1.3 ± 0.1; the mean computed energy release from XTR quanta per electron is 12.3 ± 1.0 KeV. References: 7. [93-5303]

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II. INTERPLANETARY SCIENCES

THE FIRST PANORAMAS OF THE VENUSIAN SURFACE

Moscow PERVYYE PANORAMY POVERKHNOSTI VENERY (The First Panoramas of the Venusian Surface) in Russian 1979 signed to press 20 Mar 79 pp 2, 131-132

[Annotation and table of contents from the book edited by Academician M.V. Keldysh, Nauka, 1600 copies, 132 pages]

[Text] The book contains a description of experiments on photographing the surface of Venus by Venera 9 and Venera 10 and the results of a study of the panoramas obtained.

A survey of current concepts about Venus and the results of previous investigations is given; the design of the descent vehicles, the descent schedule and the transmission of data are described, as are the television equipment and the methods of digital image processing.

The book is of interest to planetary scientists, geophysicists, space equipment specialists and students specializing in the subjects concerned.

The book includes two tables, 85 illustrations and 69 bibliographic references.

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PREDICTION OF SOME SCHEMES FOR INTERPLANETARY FLIGHTS TO THE OUTER PLANETS

Moscow TRUDY 12-kh CHTENIY, POSVYASHCH. RAZRAB. NAUCH. NASLEDIYA I RAZVITIYU IDEY K.E. TSIOLKOVSKOGO, KALUGA, SEKTS. MEKH. KOSMICH. POLETA in Russian 1979 pp 17-26

LESHCHENKO, A.V., KOTIN, V.A., PAPKOV, O.V.

[From REFERATIVNYY ZHURNAL, 62. ISSLEDOVANIYE KOSMICHESKOGO PROSTRANSTVA, OTDEL'NYY VYPUSK No 10, 1979 Abstract No 10.62.312 by V. Rudenko]

[Text] A study was made of the problem of an interplanetary flight carried out with an intermediate flight around Mars or Venus. It is shown that a perturbation maneuver near these planets will make it possible to reduce energy expenditures and improve the kinematic characteristics of the trajectory. As the optimality criterion the authors employed the total characteristic velocity required for realization of the flight. As a result of the computations it was possible to find the total flight time and the optimum calendar times for the accomplishment of such flights. An evaluation of the effectiveness of correction of an Earth-Mars-Saturn trajectory is made.
[93-5303]

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III. SPACE ENGINEERING

PHYSICAL PRINCIPLES OF SPACE ELECTROREACTION (ELECTROJET) ENGINES

Moscow FIZICHESKIYE OSNOVY KOSMICHESKIKH ELEKTROREAKTIVNYKH DVIGATELEY. TOM 1. ELEMENTY DINAMIKI POTOKOV V ERD (Physical Principles of Space Electroreaction (Electrojet) Engines. Vol 1. Elements of Dynamics of Flows in Electroreaction Engines) in Russian 1978 pp 2-16

[Annotation, foreword, introduction and table of contents of monograph by A. I. Morozov, Atomizdat, 1,550 copies, 328 pages]

[Text] Annotation. The monograph gives a description of the processes occurring during ionization and acceleration of a working medium in electroreaction (electrojet) engines. Particular attention is given to the processes of interaction of flows with walls and electrodes. The author sets forth the principal methods for computing the dynamics of ion and plasma flows under different conditions and analyzes the most important properties of these flows.

The book is intended for scientific specialists and engineers working in the field of high-energy plasma dynamics, and in particular, electrojet engines. It will be useful also for instructors at colleges and students in corresponding fields of specialization. Figures 157, 28 tables, bibliography of 197 items.

Foreword. Cosmonautics is paradoxical. To everyone it presents what at first glance are contradictory requirements. Engines are no exception. On the one hand, in order to put space vehicles into orbit it is necessary to have engines developing forces of hundreds and thousands of tons. On the other hand, for the space vehicle itself, after it has been put into orbit, it is usually sufficient to have low-thrust engines with a force measured in milligrams, grams, in an extreme case, a few kilograms. In this book we will examine the most promising low-thrust engines, electric rocket engines (electrojet engines). The principal merit of these engines is great escape velocities, unattainable for ordinary thermochemical engines.

The electrojet engine concept is exceptionally broad. It includes gas-dynamical systems (electrically heated engines), ion engines, and finally, plasma engines. A great many articles and a series of books have been devoted to electrojet engines. A distinguishing characteristic of this book is a systematic exposition of the physical aspects of electrojet engines. Here the greatest attention is devoted to problems relating to plasma engines, which, being the most complex from the point of view of the transpiring processes, at the same time are the most promising.

The basis for plasma electrojet engines is the process of plasma acceleration to velocities of about 10-100 km/sec. The obtaining of such rapid flows requires quite specific apparatus which differs qualitatively, for example, from magnetohydrodynamic generators, in which the flow velocities were substantially less. With respect to the nature of the processes, the problem of magnetohydrodynamic generators belongs to the physics of low-temperature plasma, whereas the problem of electrojet engines belongs to the physics of high-temperature (to be more precise, high-energy) plasma, which began to develop intensively in connection with the problem of controllable thermonuclear synthesis.

The modern physics of fast plasma flows with a great number of new and sometimes unexpected results has been created during the last 15-20 years. One of the important stimuli in development of this branch of physics was the electrojet engine problem. Nevertheless, the physical picture of the processes (especially in the part relating to phenomena and different kinds of oscillations near electrodes and walls) even in the most studied types of plasma electrojet engines still remains largely unclear, which is delaying the improvement of existing electrojet engines and the creation of new engines with optimum correspondence to different special requirements. Therefore, the further development of the physical picture of processes in electrojet engines is timely. The author hopes that this book will favor this.

The physical principles of electrojet engines cover a very broad range of processes and methods for their investigation. Moreover, the limits of this "range" are extremely diffuse both due to the existence of gaps in the physical picture and due to a great many fundamentally possible but at the present time for one reason or another still undeveloped schemes for electrojet engines. Therefore, the problem of choice of "basic" material for the book was quite complex and it was difficult to avoid elements of subjectivism. In preparing the plan for the book, the author was guided by modern designs of stationary plasma engines.

The book consists of two volumes. The first volume describes processes of ionization of working media, elements of the dynamics of plasma and ion flows in electromagnetic fields, and also the principal types of interaction between fast flows, the electrodes and the walls of acceleration channels. The second volume examines modern electrojet engines and the physical processes in them. It covers problems relating to interaction between electrojet engines, a space vehicle and the ionosphere and gives the elements of ballistics of space vehicles with electrojet engines.

The book does not especially go into the problems of priority in creation of electrojet engines or developments on their basis. In citations to a more detailed exposition of any problem the preference has been given to review publications.

Academician L. A. Artsimovich has repeatedly emphasized the need for a systematized exposition of the physical problems of electrojet engines. Yu. I. Danilov and V. B. Tikhonov exerted considerable efforts in order to ensure that work on this book would begin. In all stages of writing of the book I was given enormous assistance by A. K. Vinogradov. The text of Chapter 2 in this volume was written for the most part by V. A. Abramov. Individual sections of the book were read by G. I. Bakanovich, I. I. Beylis, A. I. Bushik, E. I. Kuznetsov, L. A. Latyshev, S. P. Maksimov, V. I. Rakhovskiy, V. A. Khrabrov and V. Ye. Yurasov, who made a mass of comments important for me.

Many people assisted me in the process of work on the book. In particular, I would like to note the participation of Yu. N. Ivanov, B. M. Grigorovich, A. P. Slavnova, G. P. Ilyukhina and L. V. Ryabchikova.

I am happy for the opportunity to express great appreciation to all of them.

Introduction. Electroreaction (electrojet) engines are rocket engines in which the acceleration of the working medium occurs due to the electric energy conveyed to the engine. There are several simple but fundamental factors ensuring electrojet engines a great future.

1. Thermochemical and solid-phase nuclear rocket engines are not capable of creating flows with escape velocities $\sim$10-100 km/sec which are optimum for very many problems.

2. With respect to their regulability, reserves and reliability electrojet engines even now are in many respects equal to and in the very near future should surpass classical (thermochemical) low-power jet systems.

3. The continuous complication and broadening of the problems to be solved by space vehicles are stimulating the rapid development of space (solar and nuclear) power. This process to a high degree is transpiring independently of electrojet engines. Electrojet engines are thereby receiving the principal condition for their existence -- an on-board electric power supply.

4. The development of methods for the generation of powerful ion and plasma flows, for which an ever-increasing need is felt by technologists, physicists, the creators of thermonuclear reactors, etc., is laying a solid scientific and technical basis for electrojet engines. All this taken together is indicative of the unlimited and unrelenting introduction of electrojet engines into space technology of the immediate future.

For the first time the idea of using electricity for creating a jet thrust was expressed by K. E. Tsiolkovskiy in his article: "Investigation of Universal Space With Jet Instruments," published in 1911. He wrote:

"Possibly, using electricity, it will be possible with time to impart an enormous velocity by particles ejected from a jet instrument. Even now it is known that the cathode rays in a Crooks tube, like the rays of radium, are accompanied by a stream of electrons the mass of which, as we said, is 4,000 times less [in actuality, approximately 7,500 times less] than the mass of a helium atom, and the velocity attains 30-100 thousand km/sec, that is, it is 6-20 thousand times greater than the velocity of ordinary combustion products escaping from our reaction tube."

In a book published by Hermann Oberth, entitled PATH INTO UNIVERSAL SPACE (1929), an entire chapter was devoted to electrojet engines. Oberth was the first to show that although the thrust obtained in this way would be very small, sufficiently prolonged engine operation could accelerate a rocket to great velocities.

In Leningrad, in 1929, for the first time in history work began on the designing of an electrojet engine. V. P. Glushko proposed and investigated the first impulse electrothermal engine in which the working medium, fed into the working chamber in portions, in solid or liquid form, was heated to very high temperatures by means of an electric detonation, and then escaped through a nozzle [1].

However, the intensive development of electrojet engines began only in the late 1950's. A powerful incentive for this, on the one hand, was the enormous successes in the mastery of space, and on the other hand, the progress in the physics of high-temperature plasma.

Academicians I. V. Kurchatov, L. A. Artsimovich, S. P. Korolev and A. P. Aleksandrov laid the basis for the successful development of electrojet engines in the Soviet Union. As a result, our country has the priority in creating and introduction of plasma electrojet engines in space technology. In 1964, on the interplanetary vehicle "Zond-2," impulse plasma engines were tested for the first time, and in 1972, stationary plasma engines began to operate on the "Meteor" satellite.

The first successful firings of ion engines took place in 1964 (United States, "Blue Scout" ballistic rocket). A number of important data on the functioning of ion engines under space conditions were obtained during the flights of the "Yantar'" ionospheric stations (1966-1971).

The systematic use of electrojet engines on a number of Soviet and American space vehicles began during subsequent years (see Chapter 6, Vol 2).

During the 18 years of intensive development the electrojet engine has gone a long way from extremely hazy ideas to electrojet engines successfully operating in space, these engines having unique characteristics.

Modern electrojet engines make it possible to obtain an escape velocity of more than 100 km/sec. Their operational reserve attains 10,000 hours and the number of firings can be tens of thousands (for stationary electrojet engines) or tens of millions (for pulsed electrojet engines). These engines are simple from both the design and operational points of view. They have broad limits of regulation of the principal parameters (thrust and escape velocity) without a significant change in efficiency. In ion and plasma engines it is possible to control the direction of the thrust vector without use of mechanical apparatus. Electrojet engines can operate both in a stationary regime and in short impulses (on the order of milliseconds and microseconds). The power level in modern individual stationary electrojet engine modules varies in the range from tens of watts (electrically heated, ion microengines) to hundreds of kilowatts (end engines) and for the time being there is no apparent limit to advance in the direction of both small and great powers.

The powers of electrojet engines are small in comparison with the power of modern carrier-rockets. Therefore, it seems improbable that before the year 2000 it will be possible to do without chemical engines for carrier-rockets. The engines for space vehicles put into orbit are a completely different matter. In this case, as a rule, there is usually a need for long-operating low-thrust engines developing forces of a fraction of a gram, grams or tens of grams. Only on future flights of manned interplanetary ships will the continuously developed thrust be measured in kilograms and tens of kilograms. Interest in electrojet engines and their development is attributable to the striving for an increase in the escape velocity of the working medium and thereby decreasing the expenditure of matter for a given thrust, since the thrust developed by the engine is $F = \dot{m}v$, where $\dot{m}$ is the expenditure of mass in 1 sec; v is its escape velocity. In ordinary thermochemical rocket engines the escape velocity of the combustion products does not exceed 4-4.5 km/sec, whereas a hydrogen ion, passing through a potential difference of only 1 V, acquires a velocity of about 15 km/sec. The electrojet engines now in existence easily make it possible to cover a velocity range from 2 to 8 km/sec (thermal electrojet engines) to 100 km/sec or more (electrostatic electrojet engines). However, an electrojet engine, in contrast to ordinary thermochemical engines, has a significant shortcoming, namely, that it requires a source of electric power aboard the space vehicle. Such a source can operate on the basis of either solar cells or nuclear plants (reactors, isotopic generators). The solar electric power plant, with which virtually every space vehicle is outfitted, has today received the greatest development. The power level of modern solar cells for most spacecraft falls in the range 0.1-1 KW, although, for example, in the "Skylab" system the power of the solar cells was about 20 KW. An important characteristic of the electrojet engine is the so-called energy cost of thrust, which characterizes the expenditures of power (in W) per 1 g of thrust. This "thrust cost" is directly proportional to the escape velocity and is inversely proportional to the efficiency of the electrojet engine. With an efficiency of 75% and an escape velocity of 25 km/sec the "thrust cost" is ≈ 170 W/g. Therefore, with the typical modern power plant on space vehicles the thrust of an electrojet engine may be only a few or tens of grams.

Today and in the foreseeable future electrojet engines are feasible only in a case if the time of their continuous operation is hundreds and thousands of hours. They are of special interest either for long-lived satellites which continuously must compensate perturbations (for example, drag), or for vehicles performing various maneuvers (for example, during flight to asteroids, comets, etc.). Under space conditions, where there is no friction, the low thrust, developed over a long time, leads to substantial effects. For example, an electrojet engine with a thrust of 1 g, during one revolution is capable of changing by 100 m the orbital altitude of a satellite with a mass of 1 ton (the initial orbital altitude being assumed equal to 1,000 km). However, despite the fact that at the present time there are electrojet engines which have proven themselves in space, the flights of vehicles with electrojet engines for the time being are sporadic. The large-scale use of electrojet engines is impeded by the shortage of electric power and the complexity in testing space systems. Nevertheless, the capability of electrojet engines to ensure great escape velocities, their high regulable characteristics and great reserves, and also the continuous increase in the time of active existence of a space vehicle and the progress of space power production already in the 1980's will lead to the broad penetration of electrojet engines into space.

An electrojet power plant consists of four principal units: the electrojet engine proper 1, electric power sources 2, control systems 3 and tanks with a supply of working medium and a system for feeding it into the engine 4 (Fig. 1). We will be interested primarily in the engine itself.

Dozens of designs of electrojet engines have now been described; these differ significantly from one another. Such a diversity is not only a manifestation of the unrestrained inventiveness which is inevitable in the early stage. There are considerably more serious reasons for this. The use of electromagnetic energy in different forms in combination with the possibility of accelerating neutral gas, ions, finely dispersed charged dust and plasma with the most different parameters — all this in actuality creates virtually unlimited possibilities. With time these possibilities will be used extensively for the purpose of maximum adaptation of the engine to the "natural" conditions on the space vehicle, similar to the way in which living organisms in the process of evolutionary development are more and more perfectly "fitted" into their ecological "niche." In this respect plasma engines are particularly promising, since plasma is characterized by an enormous number of internal degree of freedom. At present this peculiarity of plasma is giving researchers a great number of difficulties because for the time being there are simply not enough "eyes" and "hands" to trace all these degrees of freedom. That is why so much is said about the instability of plasma, about its "capriciousness." But, it goes without saying, the time will come when each degree of freedom will be individually traced and this will make it possible to create engines with completely surprising properties, capable with a minimum number of auxiliary systems of using the power sources and working media existing aboard the space vehicles for obtaining accelerated flows with the necessary properties.

Prior to proceeding to the main material in the book, we will give a simple classification of modern types of electrojet engines and we will describe the principal representatives of these types.

The basis for any jet engine is some process for the acceleration of matter (working medium) with its subsequent escape. Three acceleration mechanisms can be used in electrojet engines: thermal, electrostatic and electromagnetic.

Thermal electrojet engines. In these engines the electric energy serves only for heating of the working medium and its acceleration occurs the same as in ordinary rocket engines, that is, due to the drop in gas kinetic pressure. Two types of thermal electrojet engines can be distinguished: electrically heated, in which there is indirect heating of the working medium, and electric arc, in which the heat source is an arc discharge, ignited directly in the vapors of the working medium (Fig. 2).

The capacity for electric arc electrojet engines to give an appreciable gain in escape velocity in comparison with ordinary thermochemical jet engines is quite obvious -- the arc temperature can be considerably greater than the temperature of the engine walls. This favors an increase in the escape velocity.

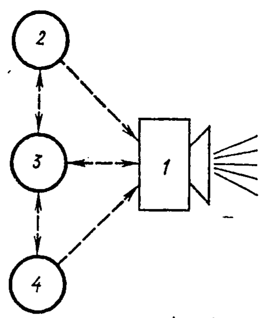

Fig. 1. Diagram of electrojet engine: 1) electrojet engine; 2) source of electric power; 3) control system; 4) tanks with supply of working medium and system for its delivery.

It can be shown that an electrically heated jet engine, in which there is indirect heating of the working medium, cannot give a gain in the escape velocity. In actuality, this is not so, since the molecular mass of a number of substances (hydrogen (H_2), ammonia (NH_3), lithium vapors, etc.) is considerably lower, for example, than water (H_2O) or carbon dioxide (CO_2), which are formed during the combustion of fuel. Thus, the possibility appears for creating engines with a great escape velocity.

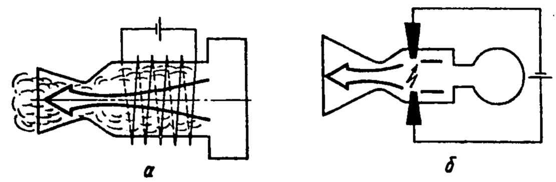

Fig. 2. Electrically heated (a) and electric arc (b) schemes for thermal electrojet engines.

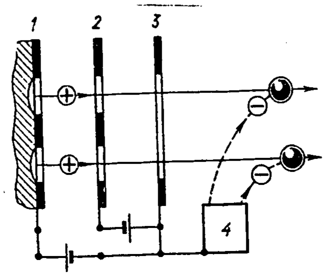

Fig. 3. Scheme for ion engine: 1) ion emitter; 2) accelerating electrode; 3) body of engine; 4) neutralizer.

It is obvious that in its properties an electrically heated electrojet engine is an ordinary thermal gas dynamic system in which the electric heaters can be replaced by any other heating systems (solar, nuclear).

Electrostatic electrojet engines. The operation of these engines essentially involves the acceleration of charged particles of the same sign by an electric field. The best-tested variants of these engines are ion engines in which positively charged ions are accelerated. There are also schemes for electrostatic engines in which instead of ions there is acceleration of small (with a diameter of several tens of A) charged droplets of fluid or dust particles. Such engines have been called "colloid" engines.

The schematic diagram of an ion engine has four principal units: ion source (emitter), accelerating electrode, outer electrode (or screen) and electron source-neutralizer (also called a cathode-compensator). The neutralizer and the outer electrode are grounded on the body of the space vehicle, whose potential is close to the potential of space (we assume arbitrarily that the latter is equal to zero); the emitter has a positive potential $+U_{emit}$, whereas the accelerating electrode has a negative potential $-U_{ac}$ (Fig. 3). Such a distribution of potentials prevents the electrons from the neutralizer from hitting the emitter. At the same time, the accelerated ions, moving away from the engine, draw electrons from the neutralizer. Therefore, despite the loss of the ions the space vehicle potential does not increase.

Existing ion engines differ from one another primarily in the method in which ions are created, that is, their ionization chambers differ. Two ionization mechanisms are of interest for modern electrojet engines. The first of these is ionization by electron impact, when a sufficiently high-energy electron impacts an atom and another electron is knocked from it. This mechanism is realized in so-called plasma-ion engines in which there is a special gas-discharge ionization chamber. The second ionization method is the ionization of atoms when they are in contact with a solid body. It occurs when the electron work function φ (that is, the energy of detachment of an electron from the emitter surface) is greater than the ionization potential (energy) I of a particular atom. For example, for tungsten φ = 4.5 eV, whereas for cesium the ionization potential I is 3.9 eV. Thus, tungsten seemingly "sucks" in an electron of the cesium atom, transforming it into an ion. The forming ion for some time remains on the surface of the tungsten until the surface, "trembling" due to thermal motion, casts it off.

In ion engines with contact ionization the ion emitter is usually a porous tungsten plate, passing through which the cesium vapors are ionized.

Electromagnetic electrojet engines. Electromagnetic jet engines are the most universal and evidently the most promising [2, 3]. Their operation is based on interaction between the magnetic field and the electric current flowing across the field. An ampere force arises as a result of such an interaction. For a linear conductor with a current this force (in gauss) is equal to

$$F = (1/c)JlH, \tag{1}$$

where J is the current strength in the conductor; l is its length; H is magnetic field strength.

All modern electromagnetic electrojet engines are of the plasma type because only in a plasma state is it possible to pass large currents through a conductor of very small mass and thereby obtain large escape velocities.

At the present time emphasis is on three classes of electromagnetic electrojet engines:

-- pulsed plasma engines;
-- stationary plasma engines with azimuthal drift;
-- stationary end engines.

Now we will examine the schemes for engines of each of these classes.

1. Figure 4 is a diagram of the simplest, so-called erosional pulsed plasma engine. The engine operates in the following way. An auxiliary bank of capacitors C_{aux} is discharged for ignition, as a result of which there is erosion of its electrodes, and weak initial plasma enters into the gap between the main electrodes across which the voltage of the main bank of capacitors C_0 is maintained. The appearance of even thin plasma near the dielectric initiates a surface discharge which begins to evaporate the dielectric.

The interaction of the discharge current with the azimuthal magnetic field proper leads to an acceleration of the plasma. After discharge of the bank C_0 the feeding of the working medium also automatically ceases.

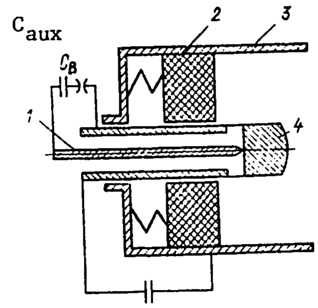

Fig. 4. Diagram of pulsed plasma erosional engine: 1) ignition; 2) dielectric; 3, 4) main electrodes.

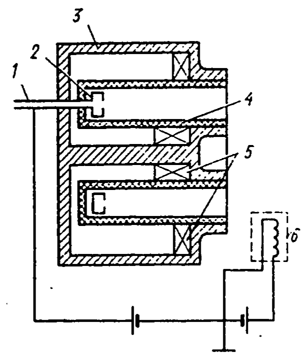

Fig. 5. Diagram of stationary plasma engine: 1) tube for delivery of working medium; 2) anode; 3) magnetic circuit; 4) dielectric channel; 5) magnetic field coils; 6) cathode-compensator (neutralizer).

2. An example of engines with azimuthal drift is the so-called stationary plasma engine; its diagram is shown in Fig. 5. The magnetic field in the channel of a stationary plasma engine is selected in such a way that the electrons are "magnetized," that is, the electron Larmor radius R_{eL} is much less than the length L and the width b of the channel, that is, $R_{eL} \ll L$, b, whereas the ions are not magnetized ($R_{iL} \gg L$). Therefore, in the channel the ions move primarily under the influence of the electric field:

$$M d\mathbf{v}_i/dt \approx e\mathbf{E}, \tag{2}$$

whereas the electrons drift in azimuth in crossed E-, H-fields. (This family of engines is called simply "stationary plasma engines" for the reason that for the time being they are the only stationary plasma engines now operating in space.)

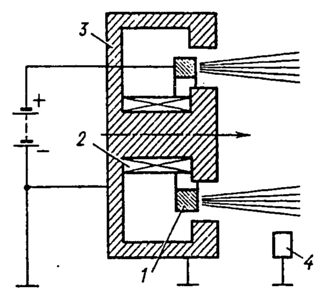

Fig. 6. Diagram of engine with anode layer: 1) anode of acceleration stage, matched with ionizer; 2) magnetic field coil; 3) magnetic circuit-cathode; 4) neutralizer.

The working process in a stationary plasma engine takes place in the following way. If the cathode-compensator is heated and the working medium is fed to the anode, a visually stable discharge flares up in the channel with the appearance of a voltage between the anode and the cathode. Neutral atoms or molecules emanating from the anode are ionized in a cloud of rotating electrons. The forming ion is captured by the electric field, is accelerated and leaves the channel. It is obvious that the mean energy of the ions passing through the entire channel should be close to the potential difference between the electrodes. An experiment confirms well this peculiarity of the the particular accelerator. An electron, arising at the time of ionization, is returned to the anode, and if it can be so expressed, after passing through the electric supply system, again encounters an ion at the output from the compensator. After this both the ion and electron leave the engine. Thus, the process of neutralization of the accelerated flow in a stationary plasma engine and in an ion engine is the same. However, in contrast to ion engines, the acceleration of ions in stationary plasma engines occurs in a cloud of electrons, which compensates the volume charge of the ions, which makes it possible to remove the restrictions associated with the volume charge. It is easy to confirm that the thrust created by the stationary plasma engine is determined by formula (1) if the azimuthally flowing electric current is substituted into it.

In addition to stationary plasma engines, in which the length of the acceleration zone can vary in a wide range, there is a variety of an engine with azimuthal drift called an engine with an anode layer (Fig. 6). The walls of the acceleration channel in such an engine are made of metal; the imparted potential difference is concentrated in a thin (of the order of the electron Larmor radius) layer near the positive electrode. In modern models engines with an anode layer are usually divided into two stages: in the first there is ionization of atoms of the working medium, whereas in the second the resulting ions are accelerated. These are higher-voltage systems than stationary plasma engines. Thus, whereas the characteristic voltages in stationary plasma engines are several hundred volts, in engines with an anode layer they are kilovolts.

3. End plasma engines are of the stationary type and exist in two physically different modifications. The first of these are powerful ($\geqslant$ 100 KW) high-current engines with an intrinsic magnetic field; the corresponding diagram is shown in Fig. 7. In a certain sense it can be said that this type of engine is a stationary variant of a pulsed plasma engine across whose electrodes a constant voltage is applied, whereas the working medium is continuously fed through a porous cathode. It would seem natural in a stationary variant as well to keep a long central electrode. However, it was found that in a stationary regime (in contrast to a pulsed regime!) the plasma is strongly pressed to the cathode (due to the Hall effect, for further details see Chapter 4 in this volume and Chapter 5 in volume 2). This makes the system virtually inoperable. However, in the "end" scheme, in which the discharge rests on the end of the cathode, compression of the plasma toward the axis in a definite range of parameters does not lead to particular difficulties. However, here also, if the discharge of matter is constant, but the discharge current increases, at some moment dangerous phenomena appear at the anode, caused by a decrease in the plasma concentration in the zone near the anode. This phenomenon has been given the name "current crisis."

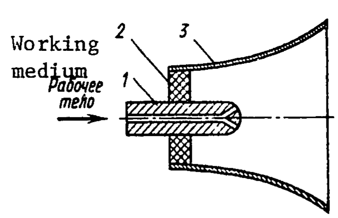

Fig. 7. Diagram of end high-current engine: 1) cathode; 2) dielectric; 3) anode.

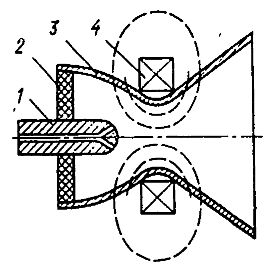

Fig. 8. Diagram of end-type Hall engine: 1) cathode; 2) dielectric; 3) anode; 4) magnetic field coil

Another type of end engines is end-type Hall engines, which are also called "magnetoplasmadynamic" engines. These are engines with an external magnetic field (Fig. 8). They, in contrast to high-current engines with an intrinsic magnetic field (Fig. 8), have high characteristics already beginning with powers of the order of several kilowatts. In end-type Hall engines the accelerating ampere force has two components:

$$f_z = (1/c)\,(j_r B_\theta - j_\theta B_r) = f_{1z} - f_{2z}. \qquad (3)$$

Both high-current engines and end-type Hall engines externally are very similar to plasmatrons. However, in contrast to the latter, they operate with substantially lesser supplies of the working medium. In end-type Hall engines there is also a "current crisis," but evidently here it can be avoided in one way or another.

Whereas in engines with azimuthal drift (as in ion engines) the energy of the ions at the output is determined by the applied potential difference U_0, in end engines it can be considerably greater than U_0, since the acceleration of ions in end-type engines is accomplished primarily due to friction against the rapidly flowing electron flow emanating from the cathode ("entrainment by the electron wind"). (For further details see #1.8.)

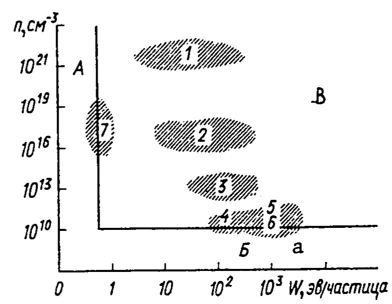

Fig. 9. Place of modern electrojet engines among different accelerators: A) gas-dynamical accelerators; B) accelerators of charged particles; 1) colloidal engines; 2) pulsed plasma engines; 3) end-type engines; 4, 5) engines with azimuthal drift; 6) ion engines; 7) thermal engines. a) W, eV/particle

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We have briefly described the schemes of types of electrojet engines which have been most tested as of today. It can be seen that they are incomparably more diverse than the schemes of modern thermochemical engines. And these are only the simplest systems for the initial period of development of electrojet engines! In this book, devoted to the physical principles of electrojet engines, the emphasis will be on processes in the zones of ionization and acceleration of modern electrojet engines. In a stationary regime these zones can be considered independently of other elements of the engine block and also independently of other engine systems. However, when oscillations arise (and in actuality, they always exist to one degree or another), the entire system is joined together, and here it is necessary to be very cautious, defining that part of the electrojet engine in which, in our opinion, the oscillation is localized.

While concerning ourselves with electrojet engines, and especially the physical processes transpiring in them, it must be remembered that they are special cases of a considerably broader range of different types of flow accelerators: gas dynamical, ion, plasma, which are being developed for the most different scientific and technical purposes. The place of modern electrojet engines among them can be judged from Fig. 9.

Our country plays a leading role in the development of plasma accelerators and plasma electrojet engines. We have invented such systems as pulsed guns, stationary high-current accelerators and accelerators with azimuthal drift. The principles of the theory of plasma flows have been laid and fundamental results have been obtained. A graphic demonstration of these attainments is the regular All-Union Conferences on Plasma Accelerators and the published materials of these conferences [4-6]. A number of books and reviews have been published in the Soviet Union which are specially or in large part devoted to electrojet engines [7-11]. The most thorough of these is the monograph [11].

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BOOK ON INDUSTRY IN SPACE

Moscow INDUSTRIYA V KOSMOSE in Russian 1978 pages unknown

[Annotation and Table of Contents from "Industriya v kosmose" by A. F. Yevich, Moskovskiy rabochiy]

[Text] Problems in using the unique conditions of space are illuminated in the book. Uses considered include: Obtaining materials with unusual physical-mechanical properties, large single crystals, super-pure materials, among them medicines, and so forth.

The book is intended for the mass readership.

Contents

6948
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INVESTIGATION OF PROGRAMS FOR CONTROL OF A SPACE VEHICLE DURING DESCENT IN THE ATMOSPHERE WITH A LATERAL MANEUVER

Moscow TRUDY 12-kh CHTENIY, POSVYASHCH. RAZRAB. NAUCH. NASLEDIYA I RAZVITIYU IDEY K.E. TSIOLKOVSKOGO, KALUGA, 1977. SEKTS. K.E. TSIOLKOVSKIY I PROBL. RAKET I KOSM. TEKHN. in Russian 1979 pp 65-69

BALANKIN, V.L., BELOKONOV, V.M., MOROZOV, L.V.

[From REFERATIVNYY ZHURNAL, 62. ISSLEDOVANIYE KOSMICHESKOGO PROSTRANSTVA, OTDEL'NYY VYPUSK No 10, 1979 Abstract No 10.62.341]

[Text] A study was made of some programs for the control of descent of a space vehicle in a fixed atmosphere relative to a fixed spherical earth in "model" trajectories (leveling out, horizontal flight and inertial gliding) with control of the banking angle, optimized for the maximum deviation L_{max} from the initial orbital plane. An allowance is made for restrictions on the maximum acceleration. The ballistic coefficient and aerodynamic quality are constant; the initial orbit is situated in the equatorial plane. Two four-stage control programs are proposed: with fixed values of the banking angle γ_i, i = 1,3,4 in three states and nonlinear control in the second $\gamma_2 = \gamma(t)$, replaceable in the second program by a linear function with the use of its derivative at the initial point of joining with restriction of the approximatation segment by the moment of coincidence of the values of the nonlinear and linear functions. The parameters to be optimized are γ_i and the course angle $\psi(t_n)$ at the end of the third stage. The conjugate gradients method is used for finding L_{max} and γ opt. A comparison with the programs with quasioptimum control and a constant banking angle is presented.
[93-5303]

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ENERGY POSSIBILITIES OF A SPACE VEHICLE USING OXYGEN-HYDROGEN FUEL

Moscow TRUDY 12-kh CHTENIY, POSVYASHCH. RAZRAB. NAUCH. NASLEDIYA I RAZVITIYU IDEY K.E. TSIOLKOVSKOGO, KALUGA, 1977, SEKTS. K.E. TSIOLKOVSKIY I PROBL. RAKET. I KOSMICH. TEKHN. in Russian 1979 pp 116-121

ZABOTIN, V.G., LEVIN, V. Ya., PERVYSHIN, A.N.

[From REFERATIVNYY ZHURNAL, 62. ISSLEDOVANIYE KOSMICHESKOGO PROSTRANSTVA, OTDEL'NYY VYPUSK No 10, 1979, Abstract No 10.62.365]

[Text] The article discusses the problem of using the mass of waste water from the on-board systems of a space vehicle as a supplement to the main fuel components of an oxygen-hydrogen rocket engine. It is proposed that this ballast mass be diverted into the rocket engine combustion chamber. A functional diagram of the afterburning system is shown. An expression is derived for computing the decrease in the realtive expenditure of components of the main fuel. The experimental results confirm a thrust increment with afterburning of the additional mass.
[93-5303]

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FLIGHT OF A VEHICLE IN A RAREFIED ATMOSPHERE AND ITS RETURN TO THE EARTH USING A CABLE LOWERED FROM AN ORBITAL STATION

Astrakhan' POLET APPARATA V RAZREZHENNOY ATMOSFERE I VOZVRASHCHENIYE YEGO NA ZEMLYU S POMOSHCH'YU TROSA, SPUSHCHENNOGO S ORBITAL'NOY STANTSII in Russian 1979 26 pages [Astrakhan' State Pedagogical Institute, Manuscript deposited at the All-Union Institute of Scientific and Technical Information 25 July 1979 No 2812-79 DEP]

POLYAKOV, G.G.

[From REFERATIVNYY ZHURNAL, 62. ISSLEDOVANIYE KOSMICHESKOGO PROSTRANSTVA, OTDEL'NYY VYPUSK No 10, 1979 Abstract No 10.62.329 DEP]

[Text] It is proposed that a space vehicle on a cable or strand (of a durable and light composition or even steel) be lowered into the rarefied atmosphere to an altitude 80-100 km from a low-flying massive orbital station. It is assumed that the station-cable-space vehicle system, oriented radially, has a good gravitational stability if the orbital station moves in a circular orbit. The space vehicle connected to the cable, with the necessary aerodynamic quality (in particular, with wings), can make prolonged flights with maneuvering in the upper atmosphere at altitudes 100-170 km. The space vehicle, since it is in sufficiently dense layers of the atmosphere, can make a soft landing on the earth without a braking engine (BE). The weight of the cable with the space vehicle can be compensated by a small increase in the velocity of motion or the orbital radius of the orbital station, and also by another cable-counterweight with a satellite on the end; it can be used for putting artificial earth satellites into higher elliptical orbits. After execution of the flight the cables are again wound onto the same drums located within the orbital station on which they were originally wound. The lowering and raising of the cable with the vehicle is accomplished by means of an electric motor which is supplied current from an on-board electric power station. The advantages of the proposed method include the possibility of making repeated and prolonged flights of space vehicles in the rarefied atmosphere in a broad range of altitudes over any regions of the earth, other planets having an atmosphere and in descent on a planetary surface without using a braking engine.
[93-5303]

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MODAL CONTROL METHOD AND ITS APPLICATION IN THE SYNTHESIS OF A SPACECRAFT STABILIZATION SYSTEM

Moscow TRUDY 12-kh CHTENIY, POSVYASHCH. RAZRAB. NAUCH. NASLEDIYA I RAZVITIYU IDEY K.E. TSIOLKOVSKOGO, KALUGA, 1977, SEKTS. MEKH. KOSMICH. POLETA in Russian 1979 pp 98-105

SIMONOV, G.I., KOZHEVNIKOV, Yu. G.

[From REFERATIVNYY ZHURNAL, 62. ISSLEDOVANIYE KOSMICHESKOGO PROSTRANSTVA, OTDEL'NYY VYPUSK No 10, 1979 Abstract No 10.62.342]

[Text] The synthesis of a space vehicle with one input and one output is subdivided into two problesm: determination of the unknown parameters of the transfer function and restoration of the vector of state; determination of the regulator adjustment coefficients. The first problem, on the assumption of complete observability of the object, is solved using an adaptive identification device (model). The "overall" asymptotic stability of the model is demonstrated by the Lyapunov direct method. The second problem is solved by the modal control method with the additional assumption of complete controllability of the object and a known type of the desired characteristic polynomial of a closed system. A structural diagram of the stabilization system is shown. The problem of whether the regulation law can be implemented using an on-board electronic computer is discussed. [93-5303]

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NEW TYPE OF ACCELERATORS

Moscow TRUDY 12-kh CHTENIY, POSVYASHCH. RAZRAB. NAUCH. NASLEDIYA I RAZVITIYU IDEY K. E. TSIOLKOVSKOGO, KALUGA, 1977, SEKTS. MEKH. KOSMICH. POLETA in Russian 1979 pp 27-33

ANDREYEV, A.V., KAMENKOV, Ye. F.

[From REFERATIVNYY ZHURNAL, 62. ISSLEDOVANIYE KOSMICHESKOGO PROSTRANSTVA, OTDEL'NYY VYPUSK No 10, 1979 Abstract No 10.62.339 by V. Rudenko]

[Text] The concept of space vehicle accelerators matched with a high-mass orbital station is examined. For the case of a chain accelerator, based on the principle of repulsion of bodies from one another, expressions were written for: 1) the law of change in distance between the elements of the chain, 2) the values of the controlling forces, 3) mass of an element, 4) law of change in the controlling forces. The authors determined the kinematic and mass limitations and derived parameters for evaluating the principal characteristics of the accelerator. The connection between the elements of the chain can be brought about by means of a material carrier or by the forces of field interaction. Data from computations for evaluating the characteristics are presented in tabular form. Recommendations on the possibility of using this type of accelerators are presented. References: 6. [93-5303]

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OPTIMUM CONTROL OF ORIENTATION OF A SPACE VEHICLE

Moscow TRUDY 12-kh CHTENIY, POSVYASHCH. NAUCH. NASLEDIYA I RAZVITIYU IDEY K.E. TSIOLKOVSKOGO, KALUGA, 1977, SEKTS. MEKH. KOSMICH. POLETA in Russian (01), 1979 pp 34-37

KUCHEROV, B.K., NIKULIN, A.M., MARKOV, V.T.

[From REFERATIVNYY ZHURNAL, 62, ISSLEDOVANIYE KOSMICHESKOGO PROSTRANSTVA, OTDEL'NYY VYPUSK No 10, 1979 Abstract No 10.62.334]

[Text] A study was made of the problem of optimum (with respect to speed) control of reorientation of the axis of an axially symmetric space vehicle by means of two pairs of jet engines creating rotational moments directed perpendicular to one another and perpendicular to the axis of the space vehicle. In order to solve the optimization problem the maximum principle is used. It is demonstrated that control, optimum with respect to speed, can be realized as relay control with not more than three switchings. A system of equations containing transcendental functions is solved for finding the switching moments.
[93-5303]

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GENERAL THEORY OF A SINGLE-PARAMETER MOVABLE BARRIER

Moscow TRUDY SEMINARA. NOVYYE METODY SPUTNIKOVOY GEODEZII. LENINGRAD, 24-30 NOYABRYA 1975 'NABLYUDENIYA ISKUSSTV. NEBESN. TEL' in Russian No 15, Part 2, 1975 (1977-1978)

LAUTSENIYEKS, L.K.

[From REFERATIVNYY ZHURNAL, 62. ISSLEDOVANIYE KOSMICHESKOGO PROSTRANSTVA, OTDEL'NYY VYPUSK No 10, 1979 Abstract No 10.62.316 by A. Mikisha]

[Text] The method for evaluating the accuracy of optical (photographic and laser) observations of artificial earth satellites, based on application of the principle of the sum of the squares of the differences between the computed and observed values, is examined. It is shown that it affords a possibility not only to evaluate the accuracy of observations with statistical rigor, but also to detect badly erroneous observations. The author uses values computed using an approximating polynomial whose degree is also selected from the principle of the minimum of the sum of nonclosure errors. The idea is expressed that there is a possibility of visual rejection of blunders using an external device for the electronic computer--a display capable of plotting curves. A study was made of the problem of search for an artificial earth satellite; this is formulated as determination of the region of admissible values of the orbital elements and orbital changes with time in phase space of the elements. This region is called the region of a movable barrier. The case of a single-parameter barrier is examined in detail. A method for constructing a movable barrier is described with satisfaction of one of two conditions: constancy of the azimuth of the ephemeridal position of the object and the constancy of its altitude. The resulting curves for the movable barrier for the culmination points of a constant azimuth form almost a right angle with the trajectory of the artificial earth satellite, which creates definite difficulties in search for and tracking of fast artificial earth satellites. It is proposed that such a curve be constructed for a movable barrier which forms a minimum angle with the trajectory of the artificial earth satellite. The possibility of applying the described method to the search for minor planets and comets is discussed. References: 44.
[93-5303]

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INVESTIGATION OF SIP-5 COORDINATE-MEASURING INSTRUMENT

Moscow ISSLED. PO GEODEZII, AEROFOTOS'YEMKE I KARTOGR. in Russian No 3/1, 1978 pp 9-15

BELOVA, N.A.

[From REFERATIVNYY ZHURNAL, 62. ISSLEDOVANIYE KOSMICHESKOGO PROSTRANSTVA, OTDEL'NYY VYPUSK No 10, 1979 Abstract No 10.62.235]

[Text] The article describes the method used and the results of investigation of the SIP-5 coordinate-measuring instrument No 68005 belonging to the Moscow Institute of Geodetic, Aerial Mapping and Cartographic Engineers for the purpose of clarifying the possibilities of its use in space geodesy. The following parameters were determined: graduation errors for the millimeter scales, linearity and mutual perpendicularity of the rule guides, run, periodic and translational errors of spiral micrometers.
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UDC 531.8+621.52

ALGORITHM FOR SYNTHESIZING THE PROGRAMMED MOVEMENT OF A JUMPING DEVICE FOR THE FLIGHT PHASE

Moscow ALGORITM POSTROYENIYA PROGRAMMNOGO DVIZHENIYA PRYGAYUSHCHEGO APPARATA DLYA FAZY POLETA in Russian 1979 pp 3-6

[Annotation, introduction and table of contents from the book "Algorithm Postroyeniya Programmnogo Dvizheniya Prygayushchego Apparata dlya Fazy Poleta" by V.V. Lapshin, Institute of Applied Mathematics imeni M.V. Keldysh, USSR Academy of Sciences, Preprint No 26, signed to press 28 February 1979, 150 copies, 53 pp]

[Text] ANNOTATION

In this work the author discusses the problem of synthesizing the programmed movement of a multilegged jumping device in the flight phase. He derives the first integrals of the equations of motion and constructs an algorithm for solving the boundary-value problem of synthesizing programmed movement for the flight phase. He demonstrates the possibility of a substantial simplification of the functioning of this algorithm for symmetrical movement of the device, and proposes a method for synthesizing the transient movement of the legs that insures an unstressed takeoff and a soft landing of the legs on the supporting surface. The algorithms were worked out by the method of mathematical modeling on a computer. The author presents the results of his calculations. The algorithm for synthesizing programmed movement is realized, using tables, for a rather extensive set of standard movement modes.

Key words: multilegged device, jump, dynamics, movement control system, mathematical modeling.

INTRODUCTION

This monograph is a continuation of the research begun in [3] on the creation of a mathematical model of the motion and the movement control system of a jumping device. The supported phase of the device's motion was discussed in [3]. In this work we construct a mathematical model of the device's motion in the flight phase and solve the problem of synthesizing programmed movement in the unsupported phase.

The subject under discussion is a device consisting of a body and four or six two-element legs, each of which has three degrees of freedom. The total mass of the legs is a noticeable percentage of the body's mass. The device's motion consists of an alternation of two phases: supported, when all its legs stand on a supporting surface and quasistatic stability occurs, and unsupported or flight, during which the center of mass moves along a ballistic trajectory. Let us require that the device's legs separate from the supporting surface without any shock and that when landing they do so quite softly and with a low absolute stopping speed (zero speed is also possible). The requirement of a soft landing of the legs' contact with the supporting surface at the moment of landing if there are errors in execution or informational errors about the actual landing area.

In the problem of synthesizing the device's programmed movement during the flight phase, it is necessary to find those values of the device's linear and angular velocity that insure the transition from the given initial position to a given final position for the leg transfer method that has been adopted.

The first integrals of the device's equations of motion (the law of the motion of the device's center of mass and the law of the conservation of the moment of momentum relative to the center of mass) are derived in Section 1, and the mathematical model of the device's spatial movement in the flight phase is constructed. In Section 2, we formulate the boundary-value problem for synthesizing the jumping device's programmed movement in the flight phase and derive an economical algorithm for its solution. We propose a method for synthesizing the transient movement of the legs that insures a shockless takeoff and the required degree of softness of the legs' landing on the supporting surface. There is also a discussion of the possibility of a substantial simplification of the operation of the algorithm for synthesizing programmed movement in the case of symmetrical movement of the device. The results of the calculations are presented in Section 3.

For standard movement moves that encompass an extensive class of the most frequently encountered equipment movement modes, we suggest that the dependence of the body's initial angular velocity on the parameters of the upcoming flight phase be kept in mind. The amount of information to be remembered is relatively small. The magnitude of the body's initial linear velocity is computed. Such an approach sharply reduces the computation time and makes it possible to solve the problem of synthesizing programmed movement for the flight phase as the device is moving.

The algorithm for synthesizing programmed movement and the mathematical model of the jumping device's spatial movement during the flight phase were realized on a BESM-6 high-speed computer, in FORTRAN.

The synthesized programmed movement can serve as a reference for the construction of an algorithm for stabilizing the body's angular movement during flight.

The author wishes to express his deep gratitude to D. Ye. Okhotsimskiy for his formulation of the problem and attention to the work.

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IV. SPACE APPLICATIONS

SOME PROBLEMS IN THE STUDY OF PHYSICAL GEOGRAPHY FROM SPACE

Moscow VESTNIK AKADEMII NAUK SSSR in Russian No 12, 1979 pp 86-94

[Article by Professor B.V. Vinogradov]

[Text] Space photographs for study of the environment were used for the first time in the early 1960's by the Aerial Methods Laboratory, which then constituted part of the USSR Academy of Sciences. The principal aspects of a space survey were also formulated at that time: horizontal integration (extensive territories imaged on one space photograph simultaneously), vertical integration (different characteristics of the lithosphere, atmosphere hydrosphere and biosphere imaged on a single space photograph), time integration (the rhythm and dynamics of natural complexes of one and the same territory imaged on successive photographs over a defined time interval).

However, 1968 must be regarded as the beginning of the development of space methods for the study of physical geography. In that year a Problems Laboratory for Aerospace Methods for Studying Physical Geography was established at Leningrad University in the Department of Atmospheric Physics. The laboratory, together with the department, during the period 1968-1972 carried out for the first time in the USSR fundamental investigations in this field. The study of physical geography from space has been defined since that time as the totality of methodological and instrumental means for studying the composition, structure, rhythm and dynamics of processes in the atmosphere, hydrosphere, lithosphere and biosphere by space images, spectra and records of the field of sunlight reflection and the earth's characteristic radiation obtained from space vehicles.

The scientific and organizational principles of aerospace studies of physical geography were laid in this laboratory. First programs were drawn up for photographing natural formations from manned spaceships, beginning with the flights of "Soyuz-5" and "Soyuz-6" in January 1969. Then the first studies were carried out for the comprehensive interpretation (geological, geomorphological and soils-geobotanical) of space photographs taken aboard "Soyuz-3" in 1968 and during subsequent manned space flights. The laboratory developed programs and carried out the first subsatellite experiments--coordinated ground, aerial and space surveys (beginning with the flights of "Soyuz-6," "Soyuz-7" and "Soyuz-8" in 1969 and "Soyuz-9" in 1970).

A factor of great importance was validation of the choice, using different representative criteria, of key sectors in the territory of the USSR which, while small in area, could provide standards for interpretation and keys for studying similar territories with a given probability and detail. As a result of this work it was possible to determine the scientific, methodological, practical, economic and social effectiveness of a space survey. Finally, the theoretical investigations into the laws of composing a space image were most important.

By the late 1960's all this made it possible to outline the principal approaches in the scientific and practical use of space studies of physical geography. [See: B.V. Vinogradov, K. Ya. Kondrat'yev, KOSMICHESKIYE METODY ZEMLEVEDENIYA (Space Methods for the Study of Physical Geography).]

Specialists in the study of physical geography from space developed an experimental research method--the coordinated subsatellite experiment. This is a synchronous (or quasisynchronous, with admissible time deviations) survey of one and the same key sectors by mutually calibrated instruments in identical spectral intervals, but at different scales and from different altitudes (ground, from aircraft and from space vehicles). Comparison of the results of subsatellite experiments ensures, in particular, a solution of the theoretical problems in the study of physical geography from space:

--the study of the atmospheric spectral transfer function;

--the investigation of regularities in optical, geometrical and thematic generalization (generalization of image details with a decrease in survey scale) of elementary natural features in creating a super-small-scale space image of the earth's surface (Fig. 1);

--the study of frequency-contrast, frequency-spatial and frequency-temporal distribution functions of the reflective and emissive characteristics of the earth's surface for the choice of optimum scales, spectral intervals, time and frequency of a survey of environmental features from a space vehicle;

--the determination of the detail and reliability of the solution to the inverse geophysical problem--identification of environmental elements from remote images of the earth's surface from a space vehicle.

The first coordinated subsatellite experiments for studying physical geography from space were carried out in the desert on the Ustyurt Plateau in November 1969 ("Soyuz-6," "Soyuz-7" and "Soyuz-8") and then in the steppes of Rostovskaya Oblast in June 1970 ("Soyuz-9"). Carrying out such experiments is quite complex in technical, organizational and methodological respects. However, the recommendations on the optimum technical and natural conditions for a space survey and the conclusions drawn on the traits of natural formations and the possibilities of studying them by space methods, obtained on the basis of coordinated subsatellite experiments, are most correct, standardized and universal. These experiments made an important scientific-methodological contribution to the technology of studying natural resources by space methods and caused great interest both in our country and abroad.

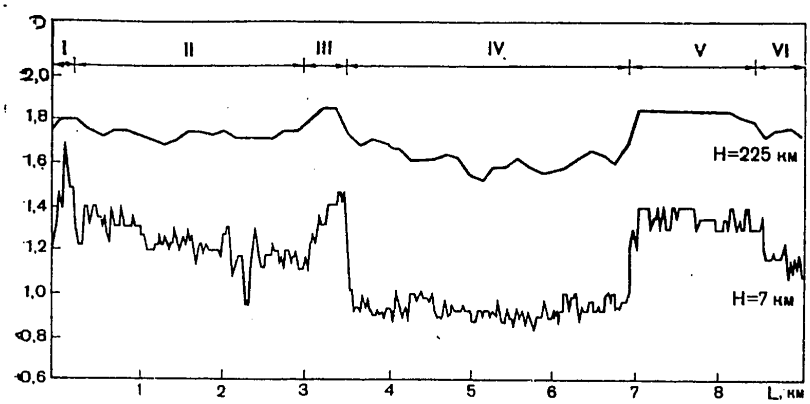

Figure 1: Geometrical generalization of details on the earth's surface on a space photograph. Comparison of microphotometric traces of optical density D on negative of space photograph obtained from "Soyuz-9" showing fields of the Sal'skiy steppe region (altitude of survey H = 225 km, scale 1:7,560,000, upper trace) and synchronized aerial photograph (survey altitude 7 km, scale 1:70,000, lower trace) along latitudinal profile L. It can be seen that with a decrease in the scale by a factor of 100 with a change from an aerial photographic survey to a space survey there is a smoothing of small details (primarily "noise") and the optical density of the atmosphere is superposed, but the principal optical contrasts between sown areas of different agricultural crops are retained, although they are somewhat lessened. I) annual grasses, II) wheat, III) annual grasses, IV) corn, V) barley, VI) perennial grasses.

As a result of carrying out coordinated subsatellite experiments and the subsequent interpretation of space images obtained in different spectral intervals--from short-wave (λ = 0.4 μm) to microwave (λ = 8.5 cm)--a number of directions in the scientific and practical use of space studies of physical geography developed during the last decade. All these directions taken together, constitute a new field in science that includes remote methods of obtaining materials for cartography, ecocoenosometry, phenology and monitoring. Beginning in 1972 these investigations were continued by various institutes, both of the USSR Academy of Sciences and other institutions, in different parts of the Soviet Union.

Spatial structures of the environment are studied by means of remote methods of obtaining materials for cartography and remote ecography (the first and most effective directions in the use of space technology). The problems involved in specialized large-scale mapping (larger than 1:300,000) in our country and in most other countries have been solved in the course of the last two decades on the basis of ordinary aerial photographic surveying.

On the other hand, general intermediate and small-scale maps (smaller than 1:300,000) were inexact and subjective. In some cases their legends did not reflect the real, but the potential or restored vegetation; in other cases, with complex multistep cartographic generalization, they accumulated too many inevitable generalization errors. Therefore, the principal contribution of space methods to cartography became the creation of the new method of intermediate and small-scale specific mapping which makes it possible to draw the boundaries of features directly from a space photograph by means of direct identification. As indicated by many years of investigations, small-scale maps compiled on the basis of space photographs have a number of advantages in comparison with maps compiled by ordinary cartographic generalization.

One of the advantages is that the schemes for photointerpretation of space photographs are characterized by a greater detail, that is, the dimensions of the features depicted on the maps which are compiled from a space photograph are 1.5-2.5 times smaller and the number of features is correspondingly greater than on an ordinary map of this same scale for this same territory. In addition, these interpretation schemes are more reliable, that is, they correspond better to the actual state of the environment than the maps compiled by in situ survey generalization methods. At the same time, map inertia (the time elapsing between the dates of registry of initial data and map publication) is reduced. Whereas earlier small-scale thematic maps reflected the state of the environment with an inertia as much as 10-15 years, the new methods reduce the lag to 3-5 years. Finally, the interpretation schemes are more specific: they better reflect (with a probability 0.9) the complex spatial mosaic of the environment and take into account its numerous anthropogenic transformations.

Another advantage of the maps compiled on the basis of space photographs is their systemic nature, both spatial and thematic. The thematic systemic nature is expressed in the integration of elements of different maps of one and the same territory. For example, the coincidence of boundaries of geobotanical and geomorphological photointerpretation schemes is 2-2.5 times better than on the old maps. Using aerial and space photographs for the first time it has been possible to present thematic mapping as a system of spatial units at different hierarchical levels: population--scale 1:1,000, biogeocenotic--1:10,000, local--1:100,000, landscape--1:1,000,000, regional--1:10,000,000 and biospheric--1:100,000,000.

Remote ecocoenosometry--the measurement of environmental characteristics on the basis of remote imaging of them from aircraft and space vehicles--is also one of the promising directions in the development of the study of physical geography from space. As a result of describing in terms of mathematical equations the relationship between a remote signal (in the visible, infrared and microwave spectral zones) and the natural characteristics of the investigated feature, a system is created which makes it possible to solve the inverse geophysical problem: the determination of environmental characteristics on the basis of reflectivity and emissivity. Remote measurements of soil moisture content and the reserve of above-ground phytomass are of the greatest interest.

As indicated by investigations, the dependence of reflectivity and emissivity of the earth's surface on soil moisture content is described in a high-gradient sector by a definite equation, regionalized on the basis of mechanical composition, covering vegetation, etc. In different spectral zones the high-gradient sectors of these changes fall in different spectral intervals. It was found that with an increase in the wavelength of the registering detector the high-gradient sector is displaced in the direction of an increase in soil moisture content (Fig.2). As a result, the multispectral method makes it possible to carry out an overall survey of soil moisture content with 4 percent gradations. This example shows that only a multispectral space survey gives results with satisfactory detail.

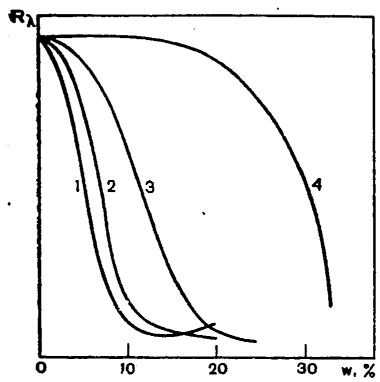

Figure 2: Remote ecocoenosometry. Curves of the dependence of a remote signal R_λ on moisture content w, percent of surface horizon of achromatic clay loam soil in different spectral zones used for remote determination of moisture content of soil. It can be seen that the high-gradient segments of the dependence in four spectral zones fall in different moisture content intervals and taken together cover the entire series of possible values of soil moisture content. 1) spectral brightness coefficient in orange-red spectral zone (with λ = 0.6–0.7μ m), 2) in near-IR spectral zone (with λ = 0.8–1.1μ m), 3) radiation temperature (with λ = 3–5 μ m) 4) radiobrightness temperature (with λ = 1.55 cm).

A mathematical equation can also be used to describe the dependence of reflectivity and emissivity of the earth's surface on the reserve of above-ground plant biomass. For example, in the visible spectral zone the dependence of the spectral brightness coefficient r_λ in the orange-red part of the spectrum (λ = 0.6–0.7μm) on the reserve of above-ground biomass of pasture vegetation m is described by the equation $r_\lambda = ae^{-bm} + ce^{dm}$. For example, for grassy-scrubby pastures against a background of light desert gray soils this equation has the form $r_\lambda = 0.3e^{-5m} + 0.05e^{0.77m}$ and in the interval m 0–10 centners/hectare gives numerical values with an error 0.5 centner/hectare. A system of such regionalized equations for different soils, seasons and atmospheric conditions provides a theoretical basis for solving one of the most important problems in studying physical geography from space--observing and predicting the development and productivity of natural vegetation and agricultural crops.

Remote phenology is the study of the rhythm of natural processes by means of repeated aerospace surveys of one and the same territory at definite time intervals. In studying the rhythm of natural processes for remote studies of physical geography, different frequencies of space surveys are used: daily, weekly, annual. A daily survey (once or twice a day) is used to record the most rapidly changing characteristics: movements of dust and sand particles in the atmosphere, structure of the temperature field of the earth's surface, etc. A weekly survey (once or twice a week) is also intended to study labile characteristics, such as movements of the snow and ice cover and changes in soil moisture content. A seasonal survey (once or twice a month) is carried out for investigating components with a greater inertia--the phenological development of vegetation.

A procedure for comparing successive aerospace photographs of one and the same territory at definite time intervals has been developed for remote phenology. In this case so-called kinetic or phenooptical maps are compiled, that is, maps of optical shifts with time corresponding to definite seasonal changes in natural characteristics. This technology includes the translation of images into a single projection, mutual calibration of the optical characteristics of images and breakdown of the image into density steps depending on the number of classes of identifiable features. As an example we will examine the method for detecting the seasonal change in the reserve of moist above-ground biomass of grass vegetation. Using an aerial photograph from the time of the first survey (summer--Fig. 3, a), a digital map is compiled showing the levels of optical density of the photographic image of the corresponding definite gradations of the moist biomass of vegetation. Then using a photograph from the second survey (autumn--Fig. 3,b), a similar digital map is created in the same projection with the very same levels of photometric characteristics and with the very same biomass gradations. The third stage is a simple readout of the maps point by point. This gives a final digital map of phenological shifts in optical density differing with respect to both sign and amplitude. Finally, in the last operation the positive density shifts caused by an increase in soil moisture content are not taken into account for solution of this problem (observation of the growing of vegetation), whereas negative shifts are interpreted as a change in moist above-ground vegetation biomass (the greater the density shift, the greater is the seasonal change in biomass--Fig.3,c). A similar method can be used for the automated observation, by remote methods, of the maturing of agricultural crops, the development of pasture vegetation, spring dessication of soils, dynamics of soil moisture content in irrigated fields, overflowing of rivers, filling of depressions with water, etc.

Remote monitoring--a system of aerospace methods for observing the state of the environment for its continuing observation, preservation and control--must be regarded as the main achievment in space methods for the study a b c

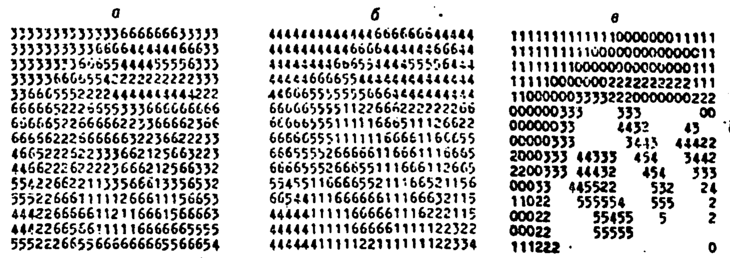

Figure 3: Remote phenology. Instrumental detection of seasonal changes in above-ground biomass of grass vegetation by means of comparison of two photographs--summer and autumn. The greater the reserve of the above-ground biomass, the greater is the difference in the optical density of summer and autumn photograph, b) digital map of levels of optical density of autumn photograph; c) digital map of negative differences of levels of optical density (a minus b) of summer and autumn photographs (the digital values on the map are negative).

of physical geography. This is a new and evidently the most promising field of application of remote methods. The principal aspect of remote monitoring is the observation of the dynamics of ecosystems subjected to the influence of man.

The most correct method for determining the dynamics of ecosystems is a comparison of aerospace photographs of one and the same territory taken in different years and the filtering out of the optical shifts corresponding to changes in the environment during this time interval. The method used in detecting changes is a photometric comparison of photographs taken in different years (Fig. 4). On the basis of the differences in optical characteristics, conclusions are drawn about such changes in natural conditions as the broadening of the area of barchan sands, reduction of the extent of pastures in the desert, the cutting down of forests, flash fires, alienation of lands for construction, etc. This method makes it possible to discriminate ecosystems in transition (requiring an annual aerospace survey), "mobile" ecosystems (once in 2 or 3 years), dynamic ecosystems (once in 5-7 years) and relatively stable ecosystems (once in 10-15 years). One of the recent attainments in space methods for the study of physical geography was the first space experiment carried out in the USSR for monitoring the dynamics of an agricultural dry steppe ecosystems in the Sal'skiy Rayon of Rostovskaya Oblast, carried out by comparing a phase photograph taken from "Soyuz-9" in 1970 and a photograph of this same territory taken from "Salyut-6" in 1978.

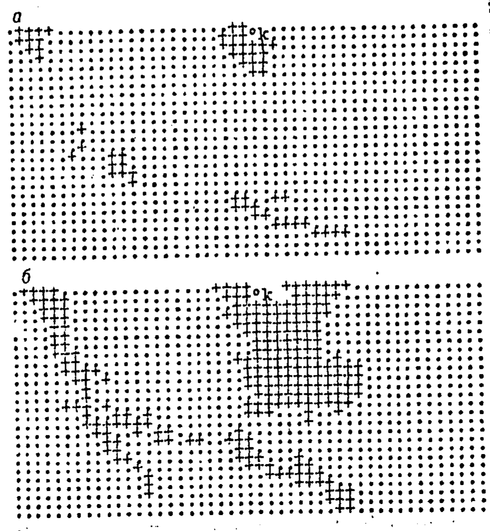

Figure 4: Remote monotoring of the dynamics of man's impact on the environment. Instrumental detection of the increase of barchan sands in a desert by comparing two images with a survey interval of 7 years. It can be seen that after 7 years as a result of man's impact the area of the sands in this region increased four-or five-fold. a) symbol map from first survey on which the barchan sands around the well °k are indicated by a "+" symbol, b) symbol map from second survey.

Another aspect of remote monitoring is the study of the spatial structure of anthropogenic effects (Fig.5) and the compilation of environmental conservation maps. Maps of the anthropogenic effects show the type of impact (pasturing, wood cutting, air contamination, etc.), the intensity of the impact (that is, the degree of economic modification) and the relationship of these types of anthropogenic effects in combinations at different levels in the organization of ecosystems--from biogeocoenoses to the biosphere as a whole.

One of the important stages in the development of space methods for the study of physical geography is determining the principal forms of its value. The scientific effectiveness of studying physical geography from space lies in the ability to obtain, on the basis of space photographs, new data on the nature of the earth's surface. For example, using this method it was possible to discover new geological lineaments and annular structures, trace the evolution of dust clouds, discover regional structures, anthropogenic changes in vegetation, etc. Space methods made it possible to introduce new definitions into the sciences of the earth and biosphere, such as the morphostructures of vegetation cover, anthropogenic lineaments, maps showing the state of changeable characteristics at a given moment in time, geographic transfer function, etc. The methodological value is expressed in an improvement in the research method with an increase in the detail and reliability of the data, an increase in the extent of coverage and representativeness of observations, in obtaining data with a minimum time inertia, etc. For example, no other method can give the distribution of changeable characteristics at a given point in time: soil moisture content, vegetation biomasses and hydrological fronts over great areas.

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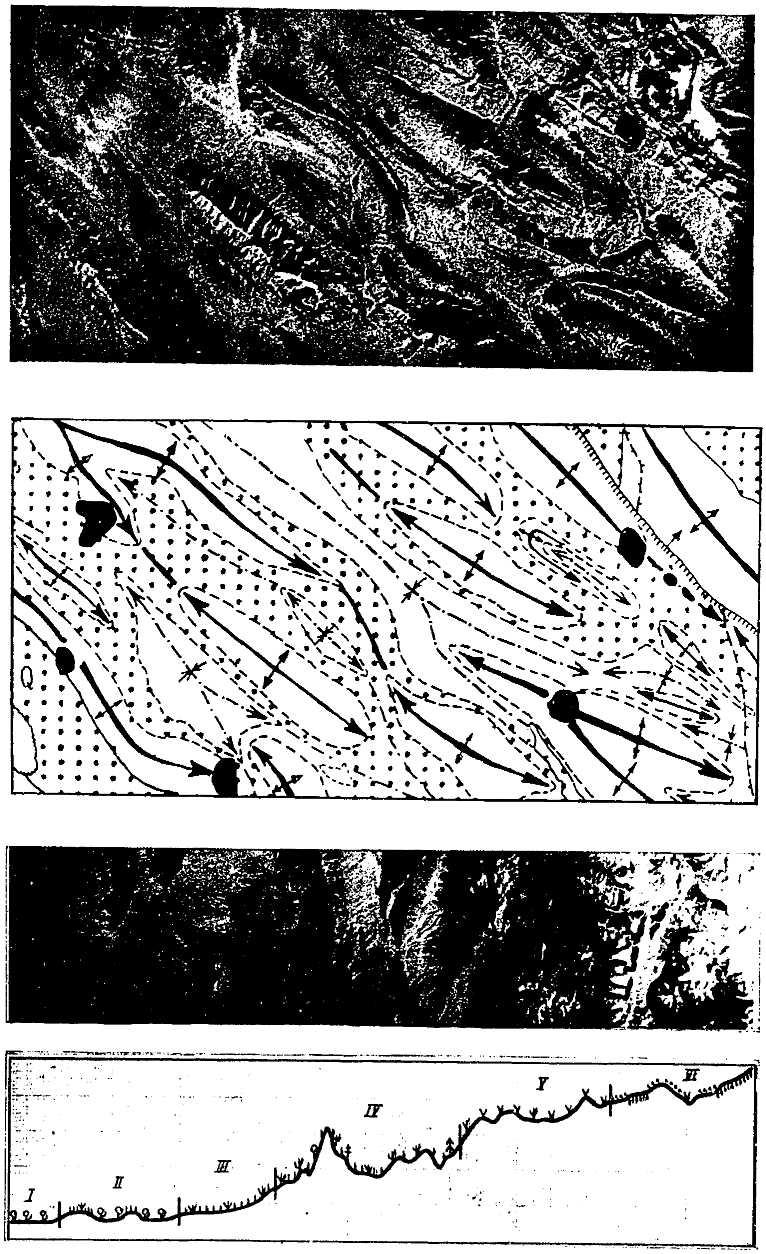
Figure 5: Remote monitoring of the structure of anthropogenic transformations of the environment. Spring space photograph of the southern part of Central Asia taken from the "Salyut-4" with a resolution of 100 m at a scale 1:2,500,000. It can be seen that in Afghanistan under conditions of unregulated pasture use the vegetation is highly disturbed (continuous light gray tone), whereas in the USSR under conditions of regulated pasturing the disturbance of vegetation is localized near wells and populated places (round light gray spots against a dark gray background).

The practical value of the new methods is due to the decrease in the expenditures of time and work on an environmental survey (for example, a survey of a territory of 100,000 km^2 from an artificial earth satellite is a thousand times more rapid than from an aircraft). The economic value consists not so much of a decrease in the cost of performing the work ("cheaper"), as is usually assumed, as in the indices of improvement in the quality of the results of scientific effectiveness, an increase in the detail and reliability of the data ("better"). But even the nominal value of just one space photograph, computed on the basis of the usual production norms, in the case of complex intermediate-scale mapping, amounts to several tens of thousands of rubles.



(Caption on following page)

CAPTION (for photograph on previous page): At top--photograph of a desert landscape taken from the manned spaceship "Soyuz-5" on 14 January 1960 in natural color without light filters, and its structural geological interpretation. The converging arrows indicate the axes of synclines; the diverging arrows indicate the axes of anticlines; the spots represent diapir structure; the "comb" symbol represents dislocations and overthrusts; the dots depict unconsolidated Quaternary deposits. At bottom--complexly colored multizonal photograph of desert agricultural landscape obtained from manned spaceship "Soyuz-22" on 15 September 1976 in conventional colors, and its corresponding topoecological profile. I) oasis with cotton fields; II) hills with desert formations of low grass ephemeroids and haloxerophilic scrub; III) foothills with semidesert formations low and high grassy ephemeroids, wormwood and scrub; IV) slopes of mountains with high grass-wormwood, mesoxerophilic scrub and scattered woody vegetation; V) high-mountains with alpine meadows and waste land; VI) mountain peaks with glaciers and snow fields

Finally, the social value of a space survey of the earth is very important. This new direction in research is stimulating the international cooperation of different countries and is orienting their efforts toward environment conservation and assistance to the developing countries in the exploitation of their natural resources and in contending with unfavorable natural phenomena (for example, clarification of the reasons for the drought in the countries to the south of the Sahara, study of ecosystems in the moist tropical forest over extensive areas of Brazil, Zaire and Indonesia, monitoring of the processes involved in advance of the desert in North Africa, prediction of the migration of locusts in East Africa, etc.)

In the USSR there have undoubtedly been successes in the study of physical geography from space. The results of investigations made during the last 10 years have been discussed in a number of monographs. [See: B.V. Vinogradov, KOSMICHESKIYE METODY IZUCHENIYA PRIRODNOY SREDY (Space Methods for Study of the Environment), Moscow, "Mysl'," 1976; G.P. Kalinin, et al., KOSMICHESKIYE METODY V GIDROLOGII (Space Methods in Hydrology), Leningrad, "Gidrometeoizdat," 1977; V.G. Trifonov, et al., GEOLOGICHESKOYE IZUCHENIYE ZEMLI IZ KOSMOS (Geological Study of the Earth From Space), Moscow, "Nauka," 1978.] However, we must also mention some shortcomings in the development of space methods for studying the environment.

For example, the study of the possibilities of a space survey for the range of biological sciences has been inadequate: in the institutes of the USSR Academy of Sciences no work is being done on the application of space methods in soil science, geobotany or animal ecology. During recent years in the study of physical geography from space there has been a predominance of empirical approaches and there has been little development of theoretical work (physical principles of remote imaging, optical and geometrical generalization, natural and technical conditions for a survey, geographical validation of representative key sectors, stochastic evaluation of the interpretation process, systematization of interpretation criteria), and without them there can be no effective solution of practical problems.

The use of remote methods for studying physical geography is faces with important problems whose solution will govern its further development. In particular, there must be fundamental investigations of the principles of remote sensing in the institutes of the USSR Academy of Sciences. Another important problem is a thoroughly effective preparation of the development program. In this stage, while retaining the principle of comprehensiveness, the programs for the remote study of physical geography must be specialized. Complexes of specific and detailed methods for remote investigations of individual environmental components must be prepared, such as for investigating the state and biomass of vegetation, moisture content and salinization of soils, individual geological engineering processes and phenomena, etc. In addition, a regionalization of programs for the remote study of physical geography is necessary. Regional programs must be drawn up for space remote sensing of the environment. The foundation for this approach has already been laid by the creation of regional automated geoinformation systems for monitoring the environment ("Pustynya," "Tayga" and other automatic monitoring systems).

We note in conclusion that the study of physical geography from space has become a scientific and methodological trend exerting an influence on the development of the sciences of the earth and its biosphere. However, its qualitative evolution and the justification of all the hopes laid on it depend on the proper organization of work, availability of professional personnel and interdisciplinary cooperation within the framework of the earth sciences and biological sciences.
[135-5303]

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SYNTHESIS OF A COLOR IMAGE FROM MULTIZONAL MASKED PHOTOGRAPHS

Moscow KOSMICH. S'YEMKA I TEMAT. KARTOGRAFIR. METODIKA OBRAB. MNOGOZONAL'N. SNIMKOV in Russian 1979 pp 45-53

KUZNETSOV, Yu.N., KOZLOVA, Ye.K., FIVENSKIY, Yu. I.

[From REFERATIVNYY ZHURNAL, 62. ISSLEDOVANIYE KOSMICHESKOGO PROSTRANSTVA, OTDEL'NYY VYPUSK No 10, 1979 Abstract No 10.62.265]

[Text] A method is proposed for synthesizing a color-coded image by using the sharp mask method in the production of each of the color-separated components. The color-separated components are obtained from a combination of a positive and negative of photographs of different spectral zones. The choice of the combination of zones is made under the condition of obtaining the maximum possible density inversions for a set of objects. The colorimetric characteristics of the resulting images are evaluated. It is noted that the combination of a positive and negative worsens the "noise properties" of the synthesized images, but it makes it possible to obtain better color separation. It is recommended that a multizonal survey be accompanied by ordinary photography in a broad spectral region for obtaining better synthesis conditions.
[93-5303]

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CSO: 1866

PRODUCTION OF COLOR ZONAL IMAGES FROM COLOR-SEPARATED NEGATIVES (POSITIVES) BY THE HYDROTYPIC AND DIAZOTYPIC METHODS

Moscow KOSMICH. S'YEMKA I TEMAT. KARTOGRAFIR. METODIKA OBRAB. MNOGOZONAL'N. SNIMKOV in Russian 1979 pp 62-66

KRAUSH, L. Ya., KOZLOVA, Ye. K.

[From REFERATIVNYY ZHURNAL, 62. ISSLEDOVANIYE KOSMICHESKOGO PROSTRANSTVA, OTDEL'NYY VYPUSK No 10, 1979 Abstract 10.62.266]

[Text] An experimental study was made of the suitability of using zonal images, tinted by hydrotypic and diazotypic methods, for synthesizing color-coded images in multizonal photography. The article describes the technological peculiarities of the processes. Both methods require the use of special equipment. The usefulness of these methods in the interpretation of multizonal photographs is noted. Their shortcomings are noted and recommendations are given.
[93-5303]

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CSO: 1866

MATHEMATICAL PROCESSING OF MULTIZONAL PHOTOGRAPHS FOR SPECIAL MAPPING

Moscow KOSMICH. S' YEMKA I TRMAT. KARTOGRAFIR. METODIKA OBRAB. MNOGOZONAL'N. SNIMKOV in Russian 1979 pp 66-72

AVERINTSEV, M.B., LUR'YE, I.K.

[From REFERATIVNYY ZHURNAL, 62. ISSLEDOVANIYE KOSMICHESKOGO PROSTRANSTVA, OTDEL'NYY VYPUSK No 10, 1979 Abstract No 10.62.267]

[Text] The authors prepared a program for the identification of images using the potential functions method for a BESM-6 electronic computer in ALGOL-60 language; this made 100 percent recognition possible. It is assumed that special interpretation of images can be achieved by a comparison of the measured spectral characteristics of geographic features with a key of spectral indicators of features. In a number of cases it is useful to select as the parameters characterizing the standard image of a feature the spatial, autocorrelation and spectral functions because they are invariant relative to movement of the images. References: 5.
[93-5303]

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STUDY OF THE ANTHROPOGENIC EFFECT ON STEPPE AND SEMIDESERT LANDSCAPES OF THE TERRITORY ADJOINING THE VOLGOGRADSKOYE RESERVOIR USING MATERIALS FROM A MULTIZONAL SURVEY FROM THE 'SALYUT-4' ORBITAL STATION

Moscow KOSMICH. S'YEMKA I TEMAT. KARTOGRAFIR. METODIKA OBRAB. MNOGOZONAL'N. SNIMKOV in Russian 1979 pp 224-230

SAYKO, T.A.

[From REFERATIVNYY ZHURNAL, 62. ISSLEDOVANIYE KOSMICHESKOGO PROSTRANSTVA, OTDEL'NYY VYPUSK No 10, 1979 Abstract No 10.62.280 by Ye. Lykasheva]

[Text] A survey was made using a photographic multizonal camera with a focal length of 80 mm and three types of film in zones with a maximum spectral sensitivity for wavelengths 0.59, 0.68 and 0.82 μm. On the photographs, in addition to such natural features as the hydrographic network, erosional dissection and desert expanses, it was possible to detect the following forms of anthropogenic modification of natural landscape conditions: urban settlements, transportation lines, plowed fields and pastures, tree farms and shelterbelts, reservoirs and canals. A determination of the type of cultivated crops and the origin of wooded areas was impossible using the photographs. Images obtained on film of type 17 with $\lambda_{eff} = 0.68 \mu$m were most informative.
[93-5303]

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CSO: 1866

INSTRUMENT FOR SYNTHESIS OF A COLOR IMAGE FROM MULTIZONAL PHOTOGRAPHS

Moscow KOSMICH. S'YEMKA I TEMAT. KARTOGRAFIR. METODIKA OBRAB. MNOGOZONAL'N. SNIMKOV in Russian 1979 pp 53-57

INDICHENKO, I.G.

[From REFERATIVNYY ZHURNAL, 62. ISSLEDOVANIYE KOSMICHESKOGO PROSTRANSTVA, OTDEL'NYY VYPUSK No 10, 1979 Abstract No 10.62.261]

[Text] The article describes the functional diagram of an instrument developed in the Aerospace Methods Laboratory of Moscow State University for the synthesis of a color image from multizonal photographs. This instrument contains a collective objective, into whose entrance window are fitted the exit windows for several (corresponding to the number of optical channels) projection objectives which by means of diagonal prisms project zonal photographs through the collective objective onto a screen with a light-sensitive material for fixing the synthesized image. It is noted that at Moscow State University specialists have fabricated a laboratory model of the instrument and that tests of the model have yielded positive results. [93-5303]

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